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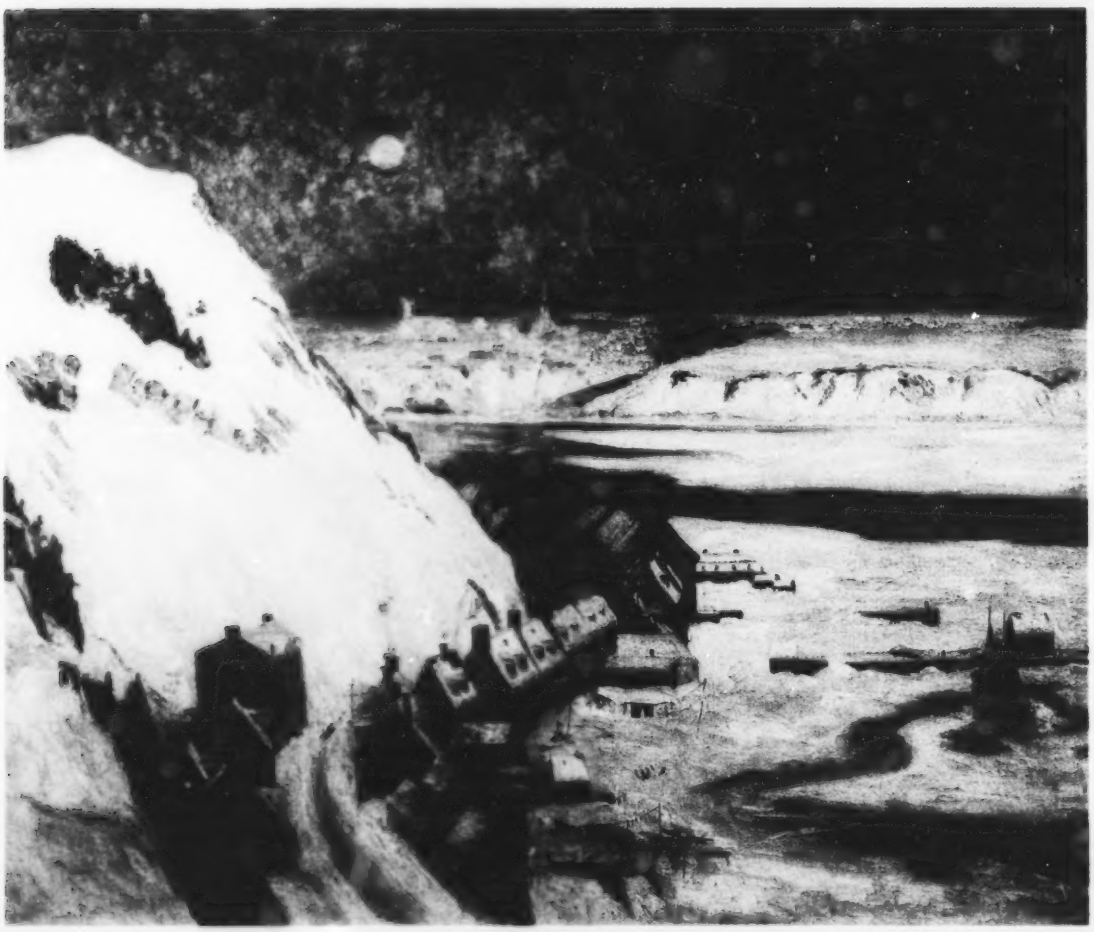

Front Cover:

Cap Diamond
Oil on canvas by Canadian artist Maurice Cullen (1866 - 1934)
Permanent collection of the Art Gallery of Hamilton
Bequest of H.L. Rinn, 1955

Photographs courtesy of Canadian Government Photocentre

Publication disponible en français sur demande

90-06296/

REFLECTIONS 1987-88

DIRECTOR'S REPORT
NATIONAL WATER RESEARCH INSTITUTE

National Water Research Institute
P.O. Box 5050
Burlington, Ontario
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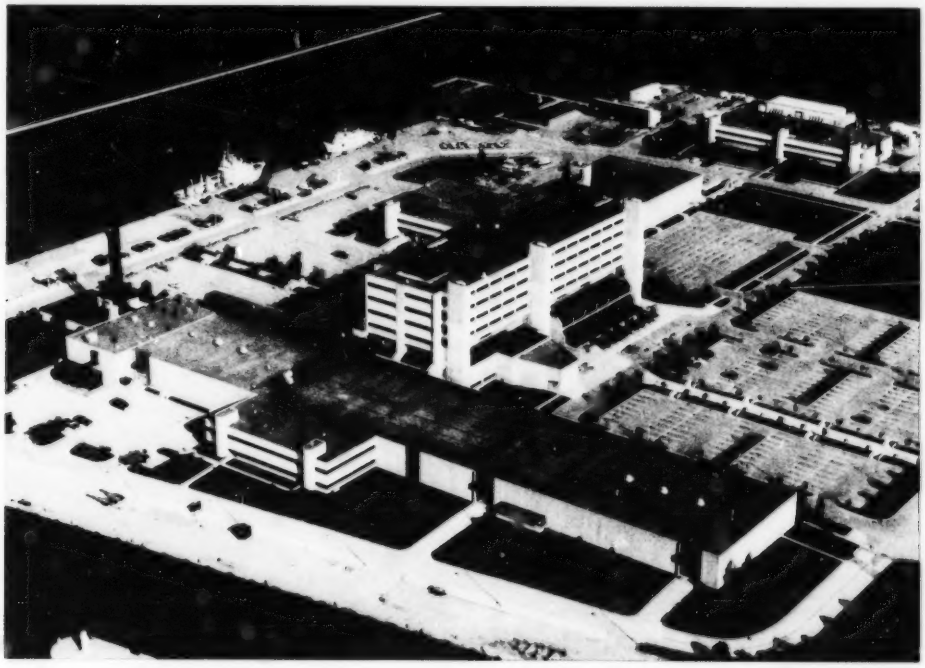
L7R 4A6

Published by the Authority of the Minister of the Environment



ABOUT NWRI

Environment Canada's National Water Research Institute (NWRI) conducts a national program of original research and development in the aquatic sciences, in partnership with the international freshwater science community. The twin goals of the Institute are

(i) to advance scientific understanding of national and international water issues important to Canada and
(ii) to develop knowledge and authoritative expertise on these issues which can be used by Environment Canada to affect decisions on the wise management of Canada's water resources.

Research at NWRI is conducted within multidisciplinary projects, each focussing on a priority issue. Projects are grouped within three branches:

- Lakes Research Branch
- Rivers Research Branch
- Research and Applications Branch.

Current long-term research priorities include:

- Toxic chemicals in the Great Lakes and the St. Lawrence River
- Exchange of toxic contaminants between air, water, sediments, and biota
- Ground-water contamination
- Pesticide contamination in rivers
- Acid rain
- Lake rehabilitation
- Development of methodologies for aquatic monitoring, ecotoxicology, and risk prediction.

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"I have heard the mermaids singing ..."

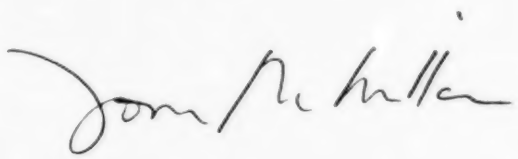
— T.S. Eliot

Scientists are privileged in that they are blessed with creative and imaginative gifts which enable them to hear and reveal nature's secret harmonies. With privilege, however, comes great responsibility. Canadians trust their scientists to provide them with an accurate understanding of environmental reality and, to meet these expectations, scientists at Environment Canada's National Water Research Institute (NWRI) are committed not only to scientific excellence but also to making their expertise and knowledge of environmental issues accessible to all Canadians. This report is part of that effort.

Canadians are concerned about environmental issues such as toxic chemicals, acid rain and water quality. They rightly expect federal leadership in the national effort to secure a healthy environment for their children and for future generations.

Leadership can take many forms. Leadership can mean strong legislation like the new *Canadian Environmental Protection Act*. It can mean innovative policy like the new Federal Water Policy. It can mean ground-breaking international agreements like the Montreal Protocol for the protection of the ozone layer or the new Great Lakes Protocol. All of these forms of leadership are built upon the strong foundation of scientific knowledge.

Canadians believe that our environmental challenges can be met successfully. They believe that if we put our minds to it we can solve our problems and provide our children with environmental security. "Putting our minds to it" is what NWRI is all about. I am proud of what the Institute has accomplished, and I take great pleasure in releasing this summary of their activities and achievements over the past year.



Tom McMillan,
P.C., M.P. Hillsborough

Minister of the Environment

TOXIC CHEMICALS

In a recent public survey, seven in ten Canadians said that they were "very concerned" about toxic chemicals in the environment. Environment Canada has long shared this concern and continues to emphasize the need to protect our living environment through proper management of chemicals. There are approximately 65 000 chemicals in existence in the world, of which about 30 000 are used in Canada.

The new *Canadian Environmental Protection Act* (CEPA) represents an important step toward environmental security. It is a comprehensive initiative to manage toxic substances through all "life cycle" stages, that is, from production of the chemical through to its disposal. The emphasis is on anticipating and preventing contamination.

An essential component of this management effort is the problem identification/assessment phase. Indeed, one of the first tasks to be undertaken within CEPA is the development of a priority substances list (approximately 50 substances). It will identify the most urgent toxic substance problems based on health and environmental factors. This list will become a public document and, in effect, dictate the chemical evaluation work of Environment Canada for a number of years.

CHEMICAL EVALUATION

If it takes several years and several million dollars to evaluate the environmental effects of one chemical, how can we ever catch up and keep up with the thousands of chemicals our society depends on?

One promising approach is called Quantitative Structure-Activity Relationships (QSAR). This refers to a methodology originally used by the chemical industry to design new chemicals so that they have specific properties and behave in predetermined ways. By using this same kind of approach we can start by specifying environmentally undesirable chemical properties and behaviour, and then work back to identify the chemicals likely to exhibit those characteristics. In this way we can screen hundreds of chemicals and home in on those most likely to cause harm.

Although still in its infancy, research combining QSAR and environmental sciences has grown quickly over the past few years. And NWRI scientists have encouraged this development. In 1983, Dr. Klaus Kaiser convened the first Workshop on QSAR in Environmental Toxicology at McMaster University. The response of the scientific community was overwhelmingly positive, and a 2nd International QSAR Workshop followed in 1986, again at McMaster. The Workshop Proceedings, edited by Dr. Kaiser, were published in 1987.

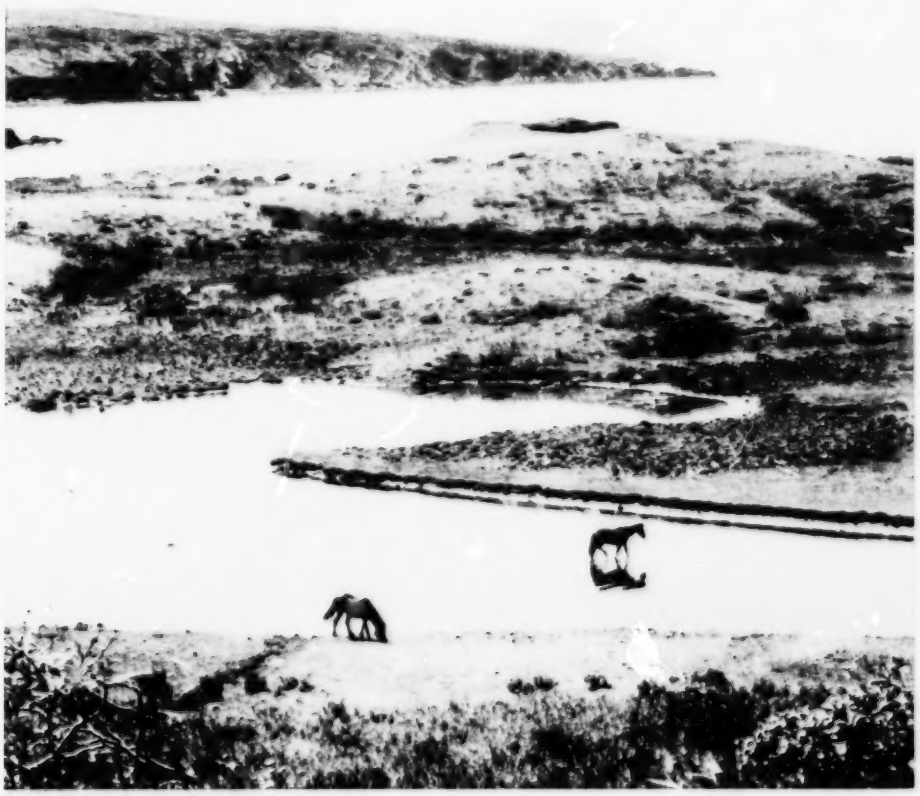
The second QSAR workshop attracted over 50 participants from nine different countries. By encouraging scientists from around the world to focus on this field of research, we hope to speed up progress in the identification of chemicals of most concern. Already, some early results are being used to identify toxic chemicals of concern in the Niagara River and Lake Ontario.

TESTING TOXICITY

Some 30 000 different kinds of chemicals are used in Canada and we know that many of them somehow find their way into our environment. How can we tell where they are building up before they cause obvious problems? There are not enough chemists and laboratories in Canada to test every river and lake for each of the 30 000 chemicals. We need a quick, simple and inexpensive way to screen water samples and to pick out those containing toxic substances. NWRI scientists have come up with a battery of tests to do the job.

For several years a team of NWRI scientists, led by Mr. Barney Dutka, has been testing 15 different screening methods to see which ones perform best at identifying poor quality water. The scientists have applied the tests in rivers, lakes and harbours across the country and have concluded that a set of five or six simple tests consistently provides good results. The tests are based on detecting the level of stress in certain organisms such as water fleas or bacteria. Although each organism may react differently to different substances, by applying the battery of five tests to each sample, those with degraded water quality are consistently identified.

The virtue of these tests is that they are easy to apply, inexpensive, and produce results rapidly. This means that we can screen samples from rivers and lakes throughout Canada and very quickly identify those requiring more detailed analysis. This battery of tests should help Environment Canada pinpoint potential problem areas and maximize the effectiveness of our labs.



Burin Peninsula, Newfoundland

SNAPPING TURTLES MAKE GOOD BIOMONITORS

In the second week of June, as she has done for 15 years, a 25-year-old snapping turtle emerges from the waters of Cootes Paradise adjacent to Hamilton Harbour, and laboriously climbs a steep hill on her way to her favorite flower bed in Hamilton's Royal Botanical Gardens. Once there, she carefully prepares her nest, deposits her eggs, and heads back to the water where she will spend the rest of the year before returning to repeat the ritual.

Because of their predictable and sedentary habits, their longevity, and their omnivorous diet, and because they accumulate high concentrations of organochlorine contaminants in both tissues and eggs, snapping turtles appear to be an ideal species for monitoring chemical contaminants. A cooperative study between scientists at NWRI, York University, and the University of Guelph is producing data to confirm this assertion.

Turtles from four disparate sites in Ontario are being investigated. Studies are determining how contaminant levels in tissues and eggs of the turtles are related to age, body size, and clutch size of nesting females. So far, the data suggest that turtles and their eggs are sensitive indicators of contaminated environments. Generally, over 90 percent of the eggs are eaten by skunks and raccoons, so that a few taken for contaminant analyses does not threaten the turtle population. Some significant relationships between contaminant levels and the characteristics of female turtles and their eggs have been observed. Hatching success and frequency of deformities in hatchlings are being monitored, and preliminary results show strong correlations between PCB concentration and reproductive failure. As snapping turtles are found throughout southern Canada, they could prove to be very useful in environmental monitoring programs.

Eastern Townships, Quebec

METALS IN WATER

"The good news is that dissolved metal concentrations in water are much lower than we thought. The bad news is that most of the dissolved metal data we have collected in the past are probably wrong - the numbers are too high." Dr. Ken Lum hastens to add that the good news is far more important than the bad news. He is discussing the implications of work he and his colleague, Dr. Jerome Nriagu, have done which shows that commonly used methods tend to overestimate by five to fifteen times the concentrations of metals dissolved in water.

High concentrations of metals in the dissolved form can be acutely toxic to aquatic organisms and to humans. Consequently, rivers and lakes across the country are monitored regularly and the data compared with water quality objectives and guidelines to ensure that problems do not develop. In this respect the only effect these new results have is to make us feel even more secure, since the real concentrations are considerably less than those we have been measuring. The potential problem, however, is for researchers attempting to detect historical trends in metal concentrations in order to determine whether water quality is getting better or worse. For them, having an accurate baseline is important.

Dr. Lum and Dr. Nriagu are holding an international conference at McMaster University in August at which this problem will be thoroughly examined.

YAMASKA RIVER - A NATURAL LABORATORY

It rises in the Appalachian Mountains in the Eastern Townships of Quebec and, in its lower reaches, traverses the rich agricultural lowlands of the St. Lawrence River into which it flows at Lac St-Pierre. The Yamaska River may be small as Quebec rivers go, with a mean annual flow of 125 cubic metres per second, but its basin is important as an agricultural centre and as the heart of Canada's textile industry. It is this agricultural and industrial activity that makes the Yamaska an ideal outdoor laboratory for some important toxic chemicals research.

Long-time residents of the basin tell stories of the river running as a rainbow of colour. The Yamaska Basin contains 11 textile mills, and each mill has an associated dyeing operation. We know very little about what happens to dyestuffs once they enter the environment, and even less about what effects they can have on aquatic life. This information is needed to satisfy the requirements of the federal *Environmental Contaminants Act*. Also, more than one quarter of all the pesticides used for agricultural purposes in Quebec are applied in the Yamaska River basin. The triazine-triazole class of pesticides is heavily used and it ranks third (out of 45) in order of priority for re-evaluation under the federal *Pest Control Products Act*.

A team of NWRI chemists and biologists, led by Dr. Jim Maguire, is using the Yamaska Basin as an experimental site to answer a wide range of questions about dyestuffs and pesticides in the aquatic environment. First, they are developing analytical methods to detect dyestuffs in water, sediment and fish. Secondly, they are using these methods to determine the occurrence of these chemicals downstream from major towns in the basin before and after the construction of municipal sewage treatment plants. Back in the laboratory, chemists are investigating the persistence and fate of 22 major dyestuffs used in the Eastern Townships. In five, small, exclusively agricultural tributaries of the Yamaska, pesticides are being measured. The scientists are investigating changing patterns of pesticide occurrence linked to changing patterns of pesticide use during the growing season. They are evaluating the suitability of various organisms as biomonitors for pesticides. Also, they are assessing the linkage between indicators of ecosystem health and of organism stress and chemical contamination in the basin.

The knowledge and experience gained in these studies will be useful across Canada in evaluating the environmental fate and effects of these chemicals.

LAMPRICIDE SAFETY ASSESSED

In the 1950s, the sea lamprey was the scourge of the Great Lakes fishery. The lamprey attach themselves to sports fish such as lake trout and feed on their blood until the fish die. In 1958, the Canada-U.S. Great Lakes Fishery Commission began using 3-trifluoromethyl-4-nitrophenol (TFM) as a lampricide to control the sea lamprey population. Since then, they have used more than 1500 tonnes of this chemical to kill juvenile stages of the sea lamprey in Great Lakes tributaries.

In support of this program, the Great Lakes Fishery Commission and the Department of Fisheries and Oceans have requested and funded past NWRI research into the persistence and fate of TFM in Great Lakes waters. The NWRI research, led by Dr. John Carey, showed that TFM degraded rapidly in the environment. Recently, however, there have been concerns raised about the presence of a previously undetected impurity in the chemical mixed with TFM during application of the lampricide. This impurity is N-methyl formamide (MMF), a toxic chemical with embryotoxic and teratogenic properties. NWRI scientists determined that the concentration of MMF in lampricide formulations ranged between 0.0001 and 0.009 percent, which suggests that less than 150 kg has been released over the 30 years of TFM treatments. From the literature on MMF toxicity, it appears that this level of release is unlikely to cause adverse effects to human and wildlife health. Moreover, the Great Lakes Fishery Commission has discontinued use of the formulation containing the impurity.

Okanagan Valley, British Columbia

CHLOROPHENOLS AND DIOXINS

Chlorophenols, which have potent biocidal properties, are heavily used as wood preservatives and are a source of concern in the Fraser River Estuary, the centre of British Columbia's lumber industry. At the request of the National Water Quality Laboratory, Dr. Bill Lee has developed a sensitive method for the simultaneous analysis of 20 chlorophenols and their corresponding chloroanisole metabolites, in water, sediment and fish. This new method will greatly facilitate the efforts of regional Environment Canada scientists to study the fate and effects of chlorophenols in the Fraser River.

The highly chlorinated phenols used in the pulp and paper industry across Canada contain dioxins as a manufacturing impurity. The most toxic form of dioxin is 2,3,7,8-TCDD. It has been detected in pulp and paper mill effluents.

Current laboratory capability cannot satisfy the demand for dioxin analysis. NWRI scientists are responding to this problem with a number of initiatives. One employs the Goulden Large Sample Extractor. Designed and built at NWRI for the preconcentration of contaminants in water samples, it is being evaluated for concentrating dioxin in samples from pulp and paper effluents. This will enable analytical instruments to detect the very low concentrations of dioxin that are of concern.

Research will continue on the adaptation of radioimmunoassay (RIA) techniques for the detection of dioxin in pulp and paper mill effluents. RIA is a very economical technique which can rapidly screen a large number of samples for the presence of dioxin and eliminate the need for more costly analysis of those that are dioxin-free. An RIA technique has been developed at NWRI which can be used to detect the presence of dioxin in fish samples.

The use of supercritical fluid extraction to simplify the clean-up procedure for the analysis of pulp and paper mill effluent samples for dioxin will be explored. Much of the cost of dioxin analysis is attributed to the time-consuming clean-up process and this research is aimed at achieving a significant cost reduction.

As soon as these methods are developed, they are transferred to the national and regional laboratories of Environment Canada for their operational use.

UPDATE: TRIBUTYLTIN BAN

Tributyltin (TBT) is an antifouling agent used in paints applied to boats and docks. It is perhaps the most acutely toxic chemical that has ever been deliberately introduced into our water. Last year we reported that NWRI research had demonstrated TBT to be persistent in Canadian waters and present in many locations at concentrations that could cause chronic toxic effects in sensitive organisms.

These results were communicated to Agriculture Canada, which administers the *Pest Control Products Act*. On October 26, 1987, Agriculture Canada announced a limited ban on the use of antifouling paints that contain TBT. This ban will help Canada avoid the experience of other countries that have large numbers of TBT-painted boats close to vulnerable fisheries.

ACID RAIN

Acid rain continues to be one of the most serious problems facing Canada. Solving it is one of the top priorities of Environment Canada and the federal government.

In March 1985, Prime Minister Mulroney announced that Canada would implement a comprehensive acid rain control program. Over the past two years, the Minister of the Environment has concluded agreements with the seven easternmost provinces which will reduce total sulphur dioxide emissions in the region to 2.3 million tonnes per year by 1994 (50 percent of the 1980 allowable levels). Regulations and programs are already in place to achieve more than 90 percent of the required reductions. Now eastern Canadian sulphur dioxide emissions are about 2.8 million tonnes, 35 percent less than in 1980.

Since more than half of the acid deposition in eastern Canada originates in the United States, Canada has been pressing for a bilateral accord. The accord would have specific emission control targets and schedules to reduce the transboundary flow of U.S. sulphur dioxide into eastern Canada to no more than two million tonnes annually - about 50 percent of the 1980 level.

Most of the environment in eastern Canada would be protected from acid rain damage if emissions and U.S. transborder flows were reduced to the levels above.

EXPERT SYSTEM IN DEMAND

How many lakes are already affected by acid rain? How many are in danger? How many will recover if we reduce acid deposition to the target load? To answer these questions and to assess the response of aquatic ecosystems to acid rain over large geographic areas, scientists need ways of manipulating and analyzing immense quantities of data. To make this easier, a team of scientists, led by Dr. David Lam of NWRI and including computer experts from the University of Guelph, have developed the microcomputer-based expert system RAISON.

RAISON simplifies data assembly and manipulation, and automatically chooses the most applicable predictive model according to internal rules specified by experts. Using interactive queries and sophisticated graphics, RAISON simplifies computer operations, so that the user can concentrate on interpreting the data. A comparative study covering all of southern Quebec showed that RAISON provides more reliable prediction of water quality and makes better use of the data than do individual models. In a recent scientific review of over 100 acid rain studies, the RAISON research was commended by an international panel as being "relevant, realistic and first class."

RAISON will be used to synthesize and interpret all of the Canadian data available on the aquatic effects of acid rain. Currently, data from all over the country are being centralized at the Institute. In addition to water quality data, the data base also contains information on land sensitivity, atmospheric deposition and biota. The data are being edited and incorporated into RAISON, after which scientists from all regions of Canada will work together to prepare a final report on the effects of acid deposition on Canadian freshwater systems. RAISON will also be used to predict how Canadian lakes would respond to specific acid rain control measures.

The RAISON system is in demand internationally for other applications. The Government of Malaysia is applying RAISON to help manage its water quality program. Dr. Lam was invited by the International Institute for Applied Systems Analysis to give a demonstration of the system in Austria. While there, he also described the system at a modelling meeting sponsored by the United Nations Environment Programme. Interest has also been expressed from the private sector, and it is clear that the flexibility and power of the system are fast becoming recognized.

TURKEY LAKES

Fifty kilometres north of Sault Ste Marie, far from any human activity, lies an undisturbed, completely forested basin surrounding four quiet pristine lakes. The Turkey Lakes Watershed was selected for intensive study precisely because the only significant human influence there has been through atmospheric deposition of chemicals. The basin receives elevated levels of acid rain and its soil is considered moderately sensitive to acidic attack.

NWRI designed a long-term study of the watershed to investigate the biogeochemical processes that occur when pollutants interact with a pristine ecosystem. The study was implemented so that computer models of the system could be develcped and validated. Many scientists from universities and other federal departments have cooperated in the study. Intensive hydrological and chemical monitoring within the watershed has allowed scientists to track chemicals through the system.

The health of the forest and of the aquatic biological community has been determined. Investigation has revealed the intricacies of physical, chemical and biological processes that control the response of the watershed to the introduction of pollutants. Models simulating watershed response have been developed and applied successfully in other basins to predict the effects of acid rain. The basin has been and continues to be a gold mine for important research. In fact, recently, a special issue of the *Canadian Journal of Fisheries and Aquatic Sciences* was published which contains 21 scientific papers on the Turkey Lakes.

QUALITY ASSURANCE PROVES ITS WORTH

With the vast array of available instruments and techniques used to analyze water samples, how can resource managers be sure that the water quality data on which they base critical decisions are accurate?

NWRI designs and conducts quality assurance (QA) programs which enable data users to evaluate the accuracy and precision of their data. Federal, provincial, municipal, university and private laboratories participate voluntarily in these programs to ensure that they are generating data of a good and comparable quality. The data used in Canada's acid rain program have been subjected to rigorous quality assurance since its inception.

This year the Institute agreed to design a new QA program for a special precipitation data set which will be collected by different researchers in Canada and the United States. The data will be used to validate the Acid Deposition and Oxidant Model, an atmospheric pollutant transport model. It was developed by the Atmospheric Environment Service of Environment Canada in cooperation with the Ontario Ministry of Environment and, more recently, German and U.S. scientists. It is considered to be the most advanced and comprehensive model available for predicting the long range movement of atmospheric pollutants. To have confidence in its predictions, however, the model must be proven by comparison with field observations. Questions have been raised about the comparability of data sets used in the past, and the collaborators agree that they need a data set that they can all trust. This is why they have commissioned this special quality assurance program which will eliminate future problems and perhaps enable existing sets to be revised.

Near Strathgartney Park, Prince Edward Island

WATER POLICY

"Our water's not for sale, Minister says," reads the headline in *The Ottawa Citizen* of November 6, 1987. The day before, Environment Minister Tom McMillan had released Canada's first comprehensive water policy. The Federal Water Policy is a statement of the federal government's philosophy and goals for the nation's freshwater resources, and of the ways it proposes to achieve them. Large-scale water export is just one of the 25 specific issues addressed by the policy. The protection and enhancement of water resources, and recognition of the true value of water are its two dominant themes.

Science leadership is featured in the policy as one of the five broad strategies for dealing with Canada's current and anticipated water issues. Scientific and socio-economic research, technological development, and data collection are all recognized as key elements in the increasingly complex process of water and related resource management.

The policy emphasizes that effective management, whether through regional planning and implementation, regulation, establishment of guidelines and codes of practice, or through leadership by example, is highly dependent upon a scientifically sound knowledge base developed in collaboration with all responsible public jurisdictions and the private sector in Canada. NWRI research reflects this emphasis.

RESEARCH LEADERSHIP

The research community has a special responsibility to contribute to the science leadership called for in the Federal Water Policy. The leadership activities of NWRI scientists this year took many forms. One fundamental responsibility is the continued commitment to scientific excellence and to effective communication of research results to the science community.

Institute scientists published over 300 reports, journal articles, and books this year, and senior researchers served as editors of such prestigious international journals as *Toxicity Assessment, Advances in Environmental Science and Technology, Science of the Total Environment,* and *Acta Hydrochimica et Hydrobiologica.*

NWRI also established the Vollenweider Lectureship in Aquatic Science, an honour granted annually, beginning in 1988, to an eminent international freshwater scientist for his or her global contribution to the advancement of the aquatic sciences.

Another effective way to influence future research directions is through the organization of conferences. Planning commenced this year for three international conferences to be held in 1988:

(i) A multidisciplinary symposium in Quebec City on the fate and effects of toxic chemicals in large rivers and their estuaries;

(ii) A conference in Burlington on trace metal contamination in lakes;

(iii) A water quality symposium in Banff, cosponsored with the World Health Organization, on microbial contamination assessment and removal from fresh waters.

To facilitate the linkage of science and policy development, staff also organized a national workshop on the relationship between emerging biological assessment methodologies and new environmental regulation. As well, NWRI scientists assisted in the design of the Water Resources Workshop for the World Conference on the Changing Atmosphere: Implications for Global Security, to be held in Toronto in June 1988.

MAKING WAVES IN WAVE RESEARCH

When the ERS-I satellite begins its orbit in 1990, ocean wave data transmitted back to earth will be analyzed by an international team of researchers led by Dr. Mark Donelan of NWRI. Dr. Donelan is recognized in the science community for his air-water interactions research. In this multi-million dollar study funded by the U.S. Office of Naval Research, 21 researchers from 16 organizations will be exploring the physics of wind-wave relationships.

The scientists hope to make both theoretical and instrumentation advances in understanding and measuring surface wave dynamics. Wave height and direction detected by satellite sensors will be used to infer wind speed and direction. This information will be compared with data collected by more traditional means, such as anchored buoys and radar-equipped aircraft, to demonstrate the reliability of the satellite approach. If the experiment is successful, satellite sensing of ocean waves could be used to provide a much more complete picture of surface winds than is currently available. Improved wind data, in turn, will enhance weather forecasts and predictions of the distribution of windborne pollutants.

Near Eganville, Ontario

ULTRA VIOLET MEANS ULTRA CLEAN

Since most of our surface waters are used as drinking water sources or for recreational purposes, sewage treatment plants usually disinfect treated water before discharging it back to the environment. The disinfectant most commonly used is chlorine which destroys 98 to 99 percent of the bacteria in the treated waste water. However, chlorine is toxic to fish and other aquatic life, and the practice of discharging water containing chlorine residuals has been questioned.

In the 1970s, Drs. John Carey and Barry Oliver of NWRI demonstrated that ultraviolet light (UV) could be used to disinfect sewage effluents. This contradicted current wisdom at the time, which held that sewage effluent contained too much particulate matter for UV disinfection to work. They showed that the UV process was effective and, although more expensive than chlorine, environmentally more acceptable.

These results attracted the attention of a small Canadian company in the business of making UV sterilizers for homes and cottages. With help from NWRI scientists and the National Research Council, Trojan Technologies Inc. embarked on a program to develop a large-scale UV sterilizer for use in municipal and industrial waste water treatment plants. By the early 1980s, development was complete and the product was ready for full-scale testing. Trojan installed their sterilizer in a treatment plant at Tillsonburg, Ontario, and thereby established the first full-scale demonstration of UV disinfection of sewage effluents. For two years, the effectiveness of the process was monitored and compared with chlorine disinfection. The results confirmed the NWRI predictions and attracted considerable interest from the treatment industry.

Trojan Technologies has become a world leader in the field of UV disinfection of waste water. Recently, they were awarded a seven million dollar contract to install UV disinfection at a new sewage treatment facility to be constructed in Quebec City. NWRI is proud to have participated in the development of this new technology, which has produced both environmental and economic benefits for Canada.

ROBOTS IN THE LAB

Heightened concern for environmental quality has led to a dramatic increase in demand for laboratory analysis of environmental samples. This has overloaded our current laboratory facilities and created a need for new, more productive analytical methods. Responding to this need, Dr. Ivan Sekerka introduced a sophisticated method called "flow injection analysis," which can process samples for major ions, trace metals and nutrients much faster than current methods. In fact, it can analyze samples so rapidly that a technician cannot prepare samples quickly enough to make effective use of the method. Enter the robot. A system consisting of a computer-controlled robot arm, a laser-based bar code label reader, and a moving sample tray has been successfully tested and will be coupled with the new method. The robotic system can process up to 300 samples per hour and permits the total automation of the analysis and data handling, thereby sharply reducing the probability of error. In the coming year scientists working on this project plan to transfer the system out of the research setting into an operational laboratory.

Vermillion Lake, Alberta

EMERGENCY RESPONSE

Scientific research creates a constant demand for new technical skills. NWRI is fortunate to have a highly trained corps of technicians possessing unique skills acquired over 15 years of solving the technical problems posed by scientists. Occasionally, these skills are required by other government departments facing emergencies or difficult situations. In the past year, two air crashes have resulted in requests for help from the Canadian Aviation Safety Board (CASB).

A twin-engined Metroliner flying toward Hamilton over Lake Ontario disappeared from Air Traffic Control radar screens during the early morning hours of February 11, 1988. A team from the Canadian Aviation Safety Board found a series of sonar targets five kilometres offshore and requested the help of NWRI's Diving Operations Unit with their unique experience in remotely controlled underwater surveillance. The NWRI team was on site within 12 hours. Over a two-day period the team provided CASB with seven hours of videotape of the crash site using their remotely controlled underwater vehicle called a miniROVER. With this information, the CASB team could prepare a dive plan for the recovery of aircraft debris.

Earlier, a Britten-Norman Islander aircraft crashed in Lake Ontario and was located by CASB, resting in 80 metres of water, three kilometres south of Toronto Island. This was a particularly difficult recovery operation, and NWRI provided engineering advice and miniROVER assistance. With the use of video images of the wreck, a special forked lifting frame was designed for the heavy-lift barge crane contracted to salvage the aircraft. The miniROVER was mounted on the frame and used to guide the crane operator in maneuvering the forks under the high wing of the aircraft. This was the first time a successful recovery had been achieved at that depth using remotely operated vehicles.

GROUND-WATER STUDIES AT U.N.B.

"Two thirds of the households in New Brunswick are supplied by groundwater. Until recently, most people considered groundwater to be a free and uncontaminated resource. In the last decade, however, the problems of supply and contamination have become everyday news items. These problems include spills and leaks from underground storage tanks and defective sanitary landfills, as well as contamination by pesticides and herbicides." Dr. Dale Bray of the University of New Brunswick (U.N.B.) was responding to a reporter's questions at the signing of a Memorandum of Understanding between the university and representatives of the federal and provincial environment departments to support the new U.N.B. Groundwater Studies Group.

In Atlantic Canada, ground-water contamination is an important issue. The demand for ground-water expertise is growing in the region and there is a shortage of facilities equipped for ground-water research. This is why U.N.B. formed the Groundwater Studies Group and why Environment Canada and its provincial counterpart joined to support its development. As one of Environment Canada's contributions, Dr. Richard Jackson of NWRI was appointed to a two-year term as the university's first adjunct professor. Dr. Jackson will give lectures and supervise graduate students and a program of research at U.N.B. This initiative will stimulate the development of expertise and the conduct of research on a high priority issue in the Maritimes.

Southwestern New Brunswick

GROUND-WATER CLEAN-UP

Between 1969 and 1980, the federal government disposed of hazardous wastes, principally organic solvents, from its Ottawa laboratories, at the Gloucester landfill located on federal land near the Ottawa airport. In 1981, a team of scientists, led by Dr. Richard Jackson, discovered a plume of contamination in the aquifer beneath the landfill. This underground plume was heading slowly toward a residential community which relied on ground water for its water supply. No wells were contaminated. Nevertheless, in 1985 the federal government shut down the private wells and put in a pipeline to incorporate the community into the municipal water supply system. Although this solved the immediate problem, the plume of contamination continues to develop, and the government is preparing a plan for decontaminating the aquifer.

Several aquifer restoration projects are currently under way in Canada. Perhaps the most impressive of these is the seven million dollar effort to decontaminate the Ville Mercier aquifer in southern Quebec by pumping the contaminated ground water out of the ground through several high capacity purge wells and treating the water on site.

A similar program is intended for the ground water beneath the Gloucester landfill. NWRI is conducting three research studies to help finalize the restoration plan.

In the first study, soils from the Gloucester aquifer were repacked into short columns and set up in a cold room at the aquifer temperature. Gloucester ground water spiked with organic contaminants was introduced into the columns and scientists tracked the progress of the toxic chemicals through the material. By simulating the behaviour of the chemicals in this way, they are able to determine how long it will take to decontaminate the aquifer to a prescribed level.

In the second study, scientists are checking the progress of the contaminant plume. They found that levels in the immediate vicinity of the disposal area had decreased compared with levels measured in 1983, although they were still very high. This decrease is attributed to dispersion of the plume throughout the aquifer. They noted that the front of the plume has now reached the boundary of the federal property. They also confirmed the presence of some very mobile and toxic compounds which they believe are being formed underground from the breakdown of other chemicals. These mobile compounds tend to move faster than other contaminants in the plume.

Finally, scientists are developing a computer model capable of simulating aquifer restoration at the site. This model will be used to identify the best arrangement of four purge wells to be used to decontaminate the aquifer over five years.

Near Leader, Saskatchewan

SAFE DRINKING WATER

Many remote communities in Canada need simple and reliable tests to ensure their water supplies are safe. This need is also shared by many developing countries. The International Development Research Centre in Ottawa funded a three-continent, seven-country study designed by NWRI to evaluate a variety of microbiological water quality assessment techniques for use with raw and potable waters. To be judged suitable, tests had to be easy to carry out with the most rudimentary equipment and produce reliable results when applied by individuals with minimal training.

The results confirmed that the safety of potable waters could be adequately tested by three simple tests: the Presence/Absence Test, the H_2S paper strip technique, and the coliphage test. The members of the Indian community at Split Lake, Manitoba, have been selected to assess these techniques. With the support of regional components of Environment Canada, Health and Welfare Canada, the Department of Indian and Northern Affairs, and the provincial government, a supply of test media will be provided to the Band, and Mr. Barney Dutka will present a one-day workshop demonstrating the procedures to members of the community. After the workshop, residents of Split Lake will be responsible for the bacteriological testing of their own water supplies. The program will be monitored and, if successful, will be applied in other isolated communities.

DRINKING WATER ODOUR

"Mississauga Residents Told to Hold Noses at Smelly Water" reads a headline in *The Toronto Star* on March 3, 1988. Such headlines reflect public concern for quality drinking water. NWRI scientists have been studying the causes of and possible remedies for odour problems in Canadian water supplies to help water utilities deal with public perceptions of the safety and acceptability of drinking water.

The most severe problems have occurred in Regina, Moose Jaw, Edmonton, and communities along western Lake Ontario, in all affecting over one million people. Many of these problems are caused by natural events.

Regina and Moose Jaw draw their raw water from Buffalo Pound Lake. This shallow productive lake usually has summertime blooms of blue-green algae which can produce a natural substance called geosmin. Geosmin was first studied extensively in Canadian water supplies by Dr. Brian Brownlee of NWRI. It can produce detectable odour in water at levels as low as 20 parts per trillion. Since 1985, the Buffalo Pound Treatment Plant has been using granular activated carbon filtration successfully to control what was once the most notorious odour problem in any Canadian water supply.

Burlington and Oakville also have suffered odour events caused by geosmin in the summer. A different odour appears during late winter in some years; 1987 was a particularly bad year. The cause has not yet been identified, but evidence points to some natural process within Lake Ontario.

Researchers at the University of Alberta have uncovered yet another type of naturally derived odour problem. In the spring of 1986, the North Saskatchewan River carried unusually high levels of dissolved organic matter from upstream runoff. This material reacted with chemicals used for disinfection of the raw water to produce compounds which caused a brief but serious odour episode in Edmonton.

UPDATE: AQUATIC WEEDS

Eurasian water milfoil, a nuisance aquatic weed which has plagued lakes in British Columbia, Ontario and Quebec, is still under control in two lakes in Ontario from which it mysteriously vanished two years ago. Last year we reported on this disappearance and attributed it to a caterpillar which appeared to be feeding on the weed. We did not know whether the caterpillar could maintain control of the milfoil. We were concerned that it might feed indiscriminately and wipe out native plants as well. So far the milfoil has remained out of sight and the native aquatic plants have returned. The caterpillar appears to be an effective biological control.

LAKE RESTORATION IN WESTERN CANADA

A way of managing sediments rich in nutrients or contaminated with toxic substances is being investigated in cooperation with private sector scientists in Western Canada. Farm dugouts on the Prairies often provide water for livestock and, in some cases, for people. These dugouts frequently develop massive algal blooms which make the water unpalatable and even toxic in extreme situations. To combat this problem, copper sulphate, an algal toxin, has been used for many years. Unfortunately, the concentrations of copper have become high enough to approach the limit for safe consumption. Also, algal populations resistant to copper are developing. A solution to both the excess algal growth and the high copper concentrations is being tested by Hydro Qual Consultants of Calgary, with support from the Alberta Department of Agriculture. Dr. Tom Murphy of NWRI is the scientific authority for the contract. The process being tested involves the application of lime to water in the dugouts. When lime is applied, a reaction occurs in which the nutrients and the copper are incorporated into a precipitate which seals the sediments. This prevents further release of the chemicals from the sediments. Early data indicate that copper and nutrient concentrations have been dramatically lowered. Follow-up work will determine whether the effect is long-lasting enough to make the restoration technique economical.

The results of this experiment are of interest to Great Lakes scientists evaluating options under consideration to treat contaminated sediments in the 17 Canadian locations designated by the International Joint Commission as Areas of Concern in the Great Lakes. There, both nutrient enrichment and toxic chemical contamination of sediments will be the major unresolved problems after external pollution sources are controlled.

GREAT LAKES AGREEMENT

On November 18, 1987, the Honourable Tom McMillan, Canadian Minister of the Environment, and Mr. Lee Thomas, Administrator of the U.S. Environmental Protection Agency, signed the 1987 Protocol to the 1978 Canada-U.S. Great Lakes Water Quality Agreement. Through their signatures, the governments of Canada and the United States reaffirmed their commitment to clean up and restore the Great Lakes.

It is significant that the basic premise of the Agreement has not changed since 1972, when it was first signed. Fundamentally, it assumes that lakes can only be restored through a concerted scientific effort to delineate the environmental imperatives of a large, complex aquatic ecosystem and the implementation of rationally devised solutions. The Protocol consists of new provisions that strengthen the two governments' attack on toxic substances with new requirements to address contaminated sediments, ground water, airborne toxic substances, and non-point sources. Each of these new provisions consists of specific research, monitoring and control components that make up the restoration and protection process.

For the research community one of the most important features of the Protocol is the new Research Annex which sets forth the research program the governments are committed to achieving. To a large extent, this will set the the Great Lakes research agenda for the foreseeable future. Dr. Rod Allan led a team of Institute staff who were instrumental in drafting this annex and contributed to many other sections of the Protocol.

It is clear from the commitments made in the Protocol that NWRI will continue to play a pivotal role in Great Lakes water quality management. Much remains to be done, and the Institute represents an internationally respected pool of expertise and knowledge with a track record of achievement in the Great Lakes. In implementing the new Protocol, the governments will again look to the Institute to provide not only knowledge and advice but also scientific leadership in the clean-up of the lakes.

Troy Lake, Manitoba

UPDATE: NIAGARA RIVER

In January 1988, the report "A Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1986-1987" was released by Environment Canada, the U.S. Environmental Protection Agency, the Ontario Ministry of the Environment, and the New York State Department of Environmental Conservation.

Dr. Abdul El-Shaarawi of NWRI chaired the multi-agency group of scientists who wrote the report. It is considered significant, as it is the first time that U.S. regulatory agencies have accepted Niagara River ambient water quality data collected by Canada.

The report presents a summary and interpretation of the Niagara River data collected between April 1986 and March 1987 from two monitoring stations operated by the Ontario Region of Environment Canada, one at each end of the river. Its completion satisfies a key requirement for the implementation of the Niagara River Toxics Management Plan and the Declaration of Intent signed in February 1987 by Mr. McMillan and Mr. Thomas.

RESEARCH SYNTHESIS - LAKE ONTARIO AND LAKE ERIE

Interpretations of results from two intensive, multidisciplinary field studies on lakes Erie and Ontario were published this year. Both research programs were prompted by the concerted effort throughout the Great Lakes Basin to reduce the amount of phosphorus entering the lakes. This huge and successful clean-up may well constitute one of the largest and most daring ecological experiments in history. To shed light on the outcome of this great experiment, scientists in Canada and the United States worked together to conduct after-the-fact studies in the two lower lakes.

The Lake Ontario results were published in a special issue of the *Canadian Journal of Fisheries and Aquatic Sciences*. This issue is devoted to integrating measurements of lake physics and nutrient availability with the response of the microbial community of Lake Ontario. Such information is vital to understanding the factors affecting the base of the food chain and in assessing the nature of the lake's response to phosphorus abatement. Dr. David Lean edited this special issue.

The Lake Erie results were published as a special issue of the *Journal of Great Lakes Research*. They show that the response of the lake, while generally acceptable, is slower than expected, particularly with respect to oxygen depletion of bottom waters. The unique character of these joint studies is summed up by Farrell Boyce in his preface to the special issue: "I take particular pleasure, now as then,in the collective nature of the enterprise that, from the planning stages to the present report, transcended international boundaries, political uncertainties, and other obstacles to demonstrate the presence of an active and effective Great Lakes scientific community."

UPDATE: HAMILTON HARBOUR RESEARCH

NWRI staff were instrumental in the production of the Hamilton Harbour Remedial Action Plan released for public comment in May 1988. Dr. Keith Rodgers chaired the multiagency writing team and many other scientists contributed original research or participated in the preparation of the report. Much of the knowledge obtained from Hamilton Harbour research can be applied at other locations in the Great Lakes and throughout the country.

Sediment traps developed by NWRI were used to measure the sedimentation rates of lake particles. In Hamilton Harbour, these rates are five to ten times those in Lake Ontario. However, the traps catch more sediment near the bottom, and this means that some of the most recent sediment is being resuspended and may eventually find its way into Lake Ontario. This may help explain why there is less sediment accumulation than expected in the harbour. PCB levels in the sediment are high in certain small areas, but throughout the harbour average levels of PCBs in sediments were found to be similar to those in Lake Ontario. Also, exceedences of water quality objectives were rare in Hamilton Harbour during 1987. Finally, according to the "Guide to Eating Ontario Sport Fish," the species tested in the harbour were no more contaminated than others from Lake Ontario. Most smelt, white perch, brown bullhead, carp and pike were edible.

Cootes Paradise is a shallow area at the west end of Hamilton Harbour. The water there is very turbid. Research at the Institute has shown that the turbidity is caused by excessive algae growth and large quantities of resuspended sediment. At these high turbidity levels the appearance of the water changes little even if the amount of suspended material is cut in half. This implies that the aesthetics of the water would not improve much even if algae were reduced by further nutrient controls.

UPDATE: ATMOSPHERIC DEPOSITION OF CHEMICALS

Last year we reported that NWRI scientists had participated in organizing an International Joint Commission Workshop on the Role of the Atmosphere as a Source of Toxic Chemicals to the Great Lakes. This year the report from the workshop was released by the Commission. One of the most disturbing suggestions in the report concerns the volatilization of chemicals from lake surfaces. The report suggests that a large portion of the PCB load in the lakes escapes from the water into the atmosphere. This massive cycling implies that many of the volatile contaminants may be beyond control once released to the environment.

In response to the recommendations of the workshop, NWRI is undertaking several new research projects. One involves establishment of an intensively instrumented master station at Point Petre on the northeast shore of Lake Ontario to develop the ability to measure atmospheric deposition accurately. The National Water Research Institute is one of many organizations collaborating at the site. The second is an experiment to quantify and model vapour exchange at the air-water interface using a unique wind/wave flume specially designed to accommodate toxic chemicals. The third is an investigation of atmospheric deposition and fate of contaminants in small, remote lakes in the Great Lakes Basin. These lakes, which only receive contaminants from the atmosphere, are being used as controls to identify the processes affecting atmospheric contaminants in the Great Lakes themselves.

Yukon landscape

REACHING OUT

Canadians today are as concerned about the quality of the environment as they are about jobs and the economy. Environmental issues such as acid rain, safe drinking water, preservation of wilderness and wildlife, pollution of the oceans, lakes, rivers and streams, toxins in food, and spills of hazardous materials affect our quality of life in every part of the country.

Environment Canada has many programs that respond to these concerns, ranging from scientific research and monitoring, to legislation and enforcement. The benefits of this work are felt by all sectors of society - other levels of government, industry, educational institutions, consultants and, most important, individual Canadians.

The success of Environment Canada's work depends on an informed public: a public that understands the threats to the environment and how these threats can be reduced or eliminated. This means that the department must effectively communicate the nature, extent and scope of environmental issues; the steps being taken to address them; and the opportunities for individuals to become involved in the process.

To achieve greater awareness, Environment Canada has stepped up its efforts to reach out to the public. Through shared programs, such as Environment Week, the department aims to involve as many citizens as possible in activities related to the environment. Throughout the department, staff are encouraged to inform Canadians about the state of their environment by the release of accurate, understandable information. The public is invited to visit Environment Canada establishments so that they can see first hand what the department is doing to protect and conserve the environment. Finally, the department is committed to holding conferences, workshops and briefings to permit open, informed discussion of important environmental issues.

NWRI welcomes this increased commitment to communication. Canadians look to the federal government for leadership on environmental issues and they say scientists are their most credible source of information. Our work at NWRI responds directly to concerns shared by people across the country and they deserve to know what we are doing on their behalf. Furthermore, Canadians say that newspapers and television are their major sources of information on the environment. It follows that if we want the public to know more about our work, we must make extra efforts to reach them through the general media. This year the National Water Research Institute has done just that.

Through an aggressive campaign to make contact with media representatives, to help them tell our story, media coverage of NWRI activities increased by 500 percent. This represented a significant new challenge for scientists at the Institute and they responded splendidly, giving over 300 interviews on their work. We are still experimenting with different approaches and learning how best to get our message across, but our commitment to communication is firm and we are convinced that we have an important and interesting story to tell.

SUSTAINABLE DEVELOPMENT

"This is the way the world ends
Not with a bang but a whimper."

— T.S. Eliot

"Today, humans are living on the edge of peril, both as a community of nations and as a species. Today, we also have perhaps the greatest potential ever for sustainable human and economic development, and that potential is expanding at rates never before experienced. But we can't seem to get our act together, and so we face a dilemma of increasing danger and expanding opportunity, and the world wonders - it has a right to wonder - which way will it jump." Those are the words of Jim MacNeill, who served as Secretary-General of the World Commission on Environment and Development. Better known as the Brundtland Commission, its members spent three years grappling with this "paradox of planetary peril and conditioned hope." In June 1986, the Commission visited Canada, and Environment Canada contributed constructively to their deliberations by presenting its report entitled "Survival in a Threatened World."

In their final report, *Our Common Future*, the Commission offered a more optimistic vision of the future than that described by T.S. Eliot above. Their report is based on the belief that people can build a future that is more prosperous, more just, and more secure. The report is not a prediction of ever-increasing environmental decay, poverty and hardship, in an evermore polluted world among ever-decreasing resources. Instead, they see the possibility for a new era of economic growth, one that must be based on policies that retain the dynamism of our economy and at the same time sustain and expand the environmental resource base. The Commission believes such growth to be absolutely essential to relieve the great poverty that is deepening in much of the developing world. The report calls for decisive political action now to begin managing environmental resources to ensure both sustainable human progress and human survival. It serves an urgent notice, based on the best scientific evidence, that the time has come to take the decisions needed to secure the resources necessary to sustain this and coming generations.

Jim MacNeill again: "Human history is the story of ingenuity and innovation, of resilience and adaptation. It is on these fundamentals, really, that the Commission rested its case that, come what may, humankind will get through the next most turbulent century. Of course, we can and do also cite a number of trends and an enormous range of scientific and technological advances that could turn the next century into a glorious renaissance, based on a cleaning and greening of the planet." Although scientific advances alone will not be sufficient, NWRI will continue to make a determined contribution to Environment Canada's effort to achieve human progress based on sustainable development.

David L. Egar
Burlington, Ontario
May 1988